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(54) DUAL NOZZLE SPRINKLER HEADS

(71) We, FACTORY MUTUAL RESEARCH CORPORATION, of 1151 Boston-Providence Turnpike, Norwood, Massachusetts, United States of America, a corporation organized and existing under the laws of the State of Massachusetts, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improved sprinkler heads and methods for operating fixed fire extinguishing systems.

Sprinkler heads conventionally used in fire extinguishing systems of the type designed to protect a building enclosure and its contents employ a nozzle through which an extinguishant such as water is passed, a heat sensitive fusible releasing device, and a deflector positioned immediately downstream of the nozzle. The deflector is designed to break up the solid jet of water issuing from the nozzle into a spray formed of small drops varying in size from less than one millimeter in diameter (e.g., several microns) to several millimeters in diameter. It is also known that the various drop size distributions within the extinguishing spray behave differently in extinguishing a fire. In the case of a large industrial fire, for example, fine drops in the spray, approximately 500 microns in diameter or less, tend to evaporate completely and serve the important function of cooling the ambient atmosphere particularly at the upper level of the building enclosure where the sprinkler heads are located. Larger drops, on the other hand, are required to penetrate the rising plume of combustion products over burning fuel surfaces to reach the surfaces and extinguish the fire. Such large diameter drops are, therefore, essential to effective extinction of a large or fast growing fire. In conventional sprays, however, there are a significant number of drops falling between these size ranges which perform neither of the useful functions aforementioned because they tend to be pushed away from the rising hot plume of combustion products and fall to the lower level of the enclosure outside the fire zone. These intermediate size drops, therefore, contribute significantly to the amount of extinguishant run-off and unwanted water damage to the protected space.

Because the operating parameters of conventional sprinkler heads are fixed, control over the size of drops in a fire extinguishant spray has been limited heretofore by variations in extinguishant pressure, which in turn determines the velocity at which the extinguishant is emitted from the sprinkler head nozzle. In general, for a given orifice size higher pressures produce a larger number of small droplets in the spray whereas coarse or large diameter droplets are developed in sprays generated under lower pressures. Pressure regulation of the water jet issuing from the nozzle is inadequate from the standpoint of developing the most efficient drop size distribution in a fire extinguishant spray, however, since an increase in pressure to produce a larger number of fine droplets results in sacrificing the number of large droplets in the spray which would penetrate the plume of combustion products and reach the fuel surfaces to extinguish the fire. Correspondingly, lowering the pressure to increase the number of large diameter drops in the spray results in the sacrifice of the ambient air-cooling function of the fine droplets whereas a compromise between high and low pressure results in an increase of the intermediate size particles contributing to run-off and water damage.

The problem of pressure balancing conventional sprinkler heads is further illustrated by tests conducted with such heads operated at normal pressures of about 40 lbs. per square inch. It was found that at this normal operating condition, less than 24% of the drops in the spray, which was discharged about 14 feet

directly above the fire, were large enough to penetrate the rising plume of a 1.5 gallons per minute gasoline spray fire. Further tests under these operating conditions indicate that an eight foot by six foot gasoline pan fire burning at a rate of about 4 gallons per minute would normally open or release up to 20 to 30 sprinkler heads spaced at ten foot intervals in two normal directions, the vast majority of which were positioned remotely from the fire. Obviously, the remote sprinkler heads not only contributed very little to ambient air-cooling but also accomplished nothing insofar as extinguishing the fire was concerned. Hence, substantially all of the water issuing from the remote sprinkler heads constituted waste-run-off of the type giving rise to severe water damage.

The present invention provides a sprinkler head for a fixed fire extinguishing system, said head comprising: a fitting having an inlet for connection to a source of extinguishant and at least two outlets, a first discharge means in one of said outlets adapted to disperse a spray of relatively fine droplets of extinguishant, and a second discharge means in the other of said outlets adapted to disperse relatively coarse droplets of extinguishant, and temperature responsive means to actuate said first and second discharge means.

The invention also provides a fixed fire extinguishing system of the type in which an extinguishant is supplied to automatically actuated sprinkler heads located in a space to be protected, and comprising a plurality of coarse spray nozzles to develop one extinguishant spray of droplets having a size capable of penetrating a rising plume of combustion products, and a plurality of fine spray nozzles to develop another extinguishant spray of fine droplets which readily evaporate and cool ambient atmosphere upon activation.

The invention further provides a method of fighting a fire comprising the step of discharging at least two streams of extinguishant towards said fire in response to information received from said fire, one of said streams being comprised substantially of finely divided droplets of extinguishant which evaporate readily to cool the ambient atmosphere, and at least one of said streams being comprised substantially of relatively large droplets of extinguishant capable of penetrating a rising plume of combustion products to reach the burning fuel surfaces of a fire.

Thus, a fire extinguishing system is provided with two types of extinguishant nozzles, one of which is designed to develop a fine spray consisting of droplets almost entirely in a range where they completely evaporate to cool the ambient atmosphere while the other nozzle of the head is designed to develop droplets of a sufficiently large diameter that they penetrate the plume of combustion products and reach the burning fuel surface thereunder to extinguish the fire. Preferably, the two types of nozzles referred to are embodied in one dual-nozzle sprinkler head but alternatively in systems using conventional, single-nozzle heads, fine spray heads will be spaced between coarse droplet heads in the space to be protected by the system.

In some instance, it is contemplated that each of the nozzles will be provided with its own temperature release device so that the respective nozzles in each head may be actuated at different temperatures. For example, the nozzle from which the fine spray is emitted may be equipped with a low temperature release to inhibit the spread of a fire whereas the coarse spray nozzle may be equipped with a high temperature release so that it will be actuated upon the development of a plume of combustion products. However, it is also possible that both nozzles may be actuated by a common release device.

Preferably the fine spray droplets are substantially all less than 1 mm. in diameter and the coarse spray droplets are larger than approximately 2 mm. in diameter.

The present invention will be further described in conjunction with the accompanying drawings, in which:

Figure 1 is a schematic illustration of three drop size distribution curves in which approximate drop diameter in an extinguishant spray is plotted against the occurrence frequency of drops by volume at the respective approximated drop diameters for conventional fire extinguishing sprinkler head;

Figure 2 is a schematic diagram similar in type to Figure 1 but depicting the spray developed in accordance with the present invention;

Figure 3 is a vertical cross section through one form of dual nozzle sprinkler head in accordance with the present invention;

Figure 4 is a side elevation in partial cross section of another form of dual nozzle sprinkler head in accordance with this invention;

Figure 5 is a vertical cross section through still another form of the dual nozzle sprinkler head of this invention;

Figure 6 is a schematic diagram showing an alternative form of fire extinguishing system in relation to a building space protected thereby; and

Figure 7 is a schematic diagram illustrating the system of Figure 6 in elevation.

Figure 1 shows three drop size distribution curves depicting the approximate drop size distribution in a fire extinguishant spray issuing from a conventional sprinkler head. Specifically, Curve I represents the drop size distribution for normal pressures of the order of 40 lbs per square inch; Curve II represents the drop diameter distribution at relatively higher pressures, and Curve III the drop diameter distribution at low pressures, it being

assumed that the same sprinkler head is used in each instance. It might be mentioned also that these curves were developed using the drop diameter in millimeters as the horizontal coordinate or abscissa and plotting the number of drops at each size respectively as the vertical axis or ordinate in terms of the relative volume of extinguishant represented by the respective drop sizes. In an extinguishant spray from a conventional sprinkler head, therefore, the drops represented by the area A in Figure 1 or less than the diameter d_c (approximately one-half millimeter) are completely evaporated under the conditions of a fire. These drops of a size greater than d_a (approximately 2.8 millimeters) and larger are represented by the area B and in practice are believed to penetrate the fire plume to reach the burning fuel source. Droplets between the diameters d_a and d_c are depicted by the areas C and D in Figure 1 which areas respectively represent droplets partly evaporated and those which tend to be pushed away from a rising hot plume of combustion products over a burning fuel source. The relatively large size of the area D as compared with the areas A, B and C is significant in that it represents the proportion of extinguishant in the spray from a conventional sprinkler head which not only contributes very little to the fire extinguishing function of the spray, but moreover contributes to water damage as run-off. On the other hand, the droplets represented by the areas A and C contribute to the fire extinguishing function by virtue of cooling ambient atmosphere through evaporation and thus inhibit the spread of the fire. Similarly, the large size droplets represented by the area B in Figure 1 contribute to the fire extinguishing function of the spray by penetrating the plume and reaching the burning fuel surfaces.

Curves II and III in Figure 1 further illustrate the problem of varying the pressure at which a spray is emitted from the nozzle of a conventional sprinkler head in that increased pressure to augment the cooling effect of the spray results in a sacrifice of available extinguishant to put out the fire at its source. Similarly, lowering the pressure to produce larger droplets within the spray gives rise to a sacrifice of the cooling by evaporation.

The distribution curve in Figure 2 illustrates the drop diameter size distribution in a fire extinguishant spray in accordance with this invention. By employing two separate nozzles, that is, a fine spray nozzle and a coarse spray nozzle, the fine spray nozzle can be selected to develop a spray in which the drop diameters are essentially all smaller than one millimeter. The volume of the spray issuing from the fine spray nozzle is depicted by the area A_1 and C_1 in Figure 2. The low pressure nozzle, on the other hand, develops a spray with a drop size diameters in excess of d_a, the volume of the spray issuing from the coarse spray nozzle being represented by area B_1 in Figure 2. It will be noted that the drops in the size range between d_c and d_a, the volume of which is represented by the area D_1 in Figure 2, is significantly reduced relative to the area D in Figure 1.

Alternative dual nozzle sprinkler head embodiments for achieving the drop size distribution represented by the curve in Figure 2 are illustrated in Figures 3—5. In the embodiment of Figure 3, the fine nozzle is a standard opposed jet nozzle 10 connected to one outlet of a T-fitting 12 having its inlet connected to a vertically disposed water supply pipe 14. A quartz bulb release 16 normally prevents the issue of water or other extinguishant through the opposed jet nozzle 10 but ruptures upon a temperature increase to open the nozzle. The coarse nozzle in the embodiment of Figure 3 takes the form of a conventional pendant nozzle 17 having a discharge opening 18 and a serrated distributor plate 20 positioned thereunder. The release in this instance is a conventional link lever release 22 having a fuse 24 and a cap 26 which moves out of the opening 18 when the temperature about the fuse 24 exceeds a predetermined amount. Since the supply of water or other extinguishant from the pipe 14 to both nozzles 10 and 17 is under the same pressure head, a restricted orifice is positioned upstream of the outlet tube 18 of the coarse nozzle to reduce the velocity and thus the effective pressure at which the extinguishant issues from the pendant coarse nozzle 17.

The quartz bulb release 16 in the embodiment of Figure 3 is preferably designed to release at a lower temperature than the fusible link 24 of the nozzle 17. In this manner, as the heat of the fire initially develops, the nozzle 10 will first open to develop a fine spray or mist, the droplets of which will immediately evaporate to cool the ambient atmosphere. This cooling action tends to slow down the release of sprinkler heads positioned in the building enclosure remotely from the fire. Then as the temperature rises the fuse link 24 releases to permit the extinguishant to pass through the pendant nozzle 17 in relatively large or coarse droplets capable of penetrating the fire plume beneath the sprinkler head to extinguish the fire.

Figure 4 shows a dual nozzle sprinkler head adapted for use with a horizontal supply line 30. In this instance an X-type fitting 32 is employed with the pendant low pressure nozzle 17 extending from a lower outlet arm 34 thereof and the fine nozzle coupled to the upwardly extending branch 36 of the fitting. The fine spray nozzle in this instance takes the form of a radial spray or fog nozzle 38 equipped with a link lever fuse release 40. The operation of the embodiment in Figure 4

is essentially the same as that of Figure 3 apart from the particular types of nozzles employed, each of which, by itself, is conventional.

In Figure 5 a further modification is illustrated wherein both fine spray and coarse nozzles are adapted to be actuated by a common release 42. The nozzles are identical in type to the corresponding nozzles 10 and 17 in the embodiment of Figure 3, but a valve member 44 having a serrated skirt 46 and a stem 48 is seated upwardly against the supply line 14. Upon actuation, the valve moves downwardly so that the serrated skirt 46 thereof rests on the restricted orifice plate 28, thereby opening both nozzles. The operation of the device to develop the fine and coarse sprays as aforementioned is the same as that described above with respect to Figure 3, with the exception that there is no difference in release temperatures as afforded by the embodiment of Figure 3.

The use of dual nozzle sprinkler heads of the type shown in Figures 3—5 is preferred because of the facility offered thereby for installation. In other words, each of the dual nozzle sprinkler heads, being a unit by itself, is simply installed according to specification without having to rely on individual workmen to effect proper positioning of the respective fine and coarse spray nozzles. It is possible, however, that separate single nozzle heads be used and arranged in a manner to effect the basic fire extinguishing technique of this invention. Such an arrangement is shown in Figures 6 and 7 of the drawings.

As shown in Figure 6, a plurality of coarse nozzle sprinkler heads 50 are arranged in conventional fashion beneath the ceiling 52 of a building space 54 to be protected. An extinguishant such as water is supplied to the coarse nozzle heads 50 in conventional fashion by main and branch lines 56 and 58, respectively. Also provided in the ceiling of the building enclosure 54 are fine spray nozzle heads 60 spaced between the coarse spray heads 50. Although the fine spray heads 60 could be supplied with an extinguishant such as water from the pipes 56 and 58 through use of suitable connections, the fine spray nozzle heads 60 in the system shown in Figure 6 are supplied with extinguishant by independent pipes depicted by dash lines 62. The use of separate supply lines is advantageous in that the line pressures supplying the respective coarse and fine nozzle heads 50 and 60 can be adjusted independently. The operation of the system shown in Figures 6 and 7, which is essentially similar to that of the dual nozzle sprinkler heads described above, is depicted in Figure 7 of the drawings. As shown, the existence of a fire plume 63 will activate automatically one or more of the coarse heads 50 thereover to provide a spray of large droplets 64 to penetrate the fire plume 63, reach the burning fuel surfaces 66 and extinguish the fire. In the meanwhile, fine nozzle sprinkler heads 60 in the vicinity of the activated coarse nozzle head or heads 50 will be activated to disperse a fine spray 68 consisting essentially of small droplets which evaporate readily. The evaporation of these fine droplets will tend to cool the interior of the building space 54 particularly along the ceiling 52 thereof. As a result, only those coarse nozzle sprinkler heads 50 which are required to extinguish the fire 63 will be activated. Not only will this mode of operation avoid unnecessary water damage due to remote sprinkler heads being actuated ineffectively but also the inactive condition of the remote sprinkler heads will serve to ensure an ample supply of water to the sprinkler heads actuated directly by the heat of the fire.

Thus it will be appreciated that we have provided an extremely effective method and apparatus for developing a fire extinguishing spray. By the use of fine and coarse spray nozzles, the drop size distribution in the spray developed by the sprinkler system is effective both from the standpoint of providing a fine spray or mist for cooling the atmosphere over a fire and as well to provide drop sizes sufficiently large in size to penetrate a fire plume and reach the burning fuel surfaces thereof. Also and equally significant, the amount of extinguishant run-off due both to particle size distribution and unnecessary release of remote sprinkler heads is reduced to a minimum.

WHAT WE CLAIM IS:—

1. A sprinkler head for a fixed fire extinguishing system, said head comprising: a fitting having an inlet for connection to a source of extinguishant and at least two outlets, a first discharge means in one of said outlets adapted to disperse a spray of relatively fine droplets of extinguishant, and a second discharge means in the other of said outlets adapted to disperse relatively coarse droplets of extinguishant, and temperature responsive means to actuate said first and second discharge means.

2. A sprinkler head as claimed in claim 1 including means for supplying extinguishant from said inlet to said second discharge means at a lower pressure than to said first discharge means.

3. A sprinkler head as claimed in claim 2 wherein said means for supplying extinguishant at a lower pressure comprises a restricted orifice in said other outlet.

4. A sprinkler head as claimed in claim 1, 2 or 3 wherein said temperature responsive means comprises separate fuse elements for each of said first and second discharge means.

5. A sprinkler head as claimed in claim 4 wherein the fuse element for said first discharge means is releasable at a lower tem-

perature than the fuse element for said second discharge means.

6. A sprinkler head as claimed in any of claims 1 to 5 comprising a valve member normally blocking said inlet, said valve member being movable under the control of said temperature responsive means to an open position establishing fluid communication between said inlet and both said discharge means.

7. A sprinkler head substantially as herein described and shown in Figures 3, 4 or 5 of the accompanying drawings.

8. A fixed fire extinguishing system of the type in which an extinguishant is supplied to automatically actuated sprinkler heads located in a space to be protected and comprising a plurality of relatively coarse spray nozzles to develop one extinguishant spray of droplets having a size capable of penetrating a rising plume of combustion products, and a plurality of relatively fine spray nozzles to develop another extinguishant spray of fine droplets which readily evaporate and cool ambient atmosphere upon activation.

9. A system as claimed in claim 8 wherein both said relatively coarse spray nozzles and said relatively fine spray nozzles are included in each of a plurality of sprinkler head units.

10. A system as claimed in claim 8 including separate means for supplying extinguishant to said relatively coarse nozzles respectively.

11. A system as claimed in claim 8, 9 or 10 including respective first temperature-responsive elements controlling the relatively coarse spray nozzles and respective second temperature responsive elements controlling the relatively fine spray nozzles.

12. A system as claimed in claim 8, 9 or 10 including first means automatically responsive to a fire in said space for controlling the opening of said relatively coarse spray nozzles, and second means automatically responsive to a fire in said space for controlling the opening of said relatively fine spray nozzles, said second means opening said relatively fine spray nozzles in advance of the opening of said relatively coarse spray nozzles by said first means.

13. The apparatus recited in claim 12 wherein said relatively coarse and relatively fine spray nozzles and said first and second means are included in each of a plurality of sprinkler head units, said first and second means being responsive to heat generated by the fire.

14. A fixed fire extinguishing system comprising a plurality of sprinkler heads as claimed in any of claims 1 to 7 and means for supplying extinguishant thereto.

15. A method of fighting a fire comprising the step of discharging at least two streams of extinguishant towards said fire in response to information received from said fire, one of said streams being comprised substantially of relatively fine droplets of extinguishant which evaporate readily to cool the ambient atmosphere, and at least one other of said streams being comprised substantially of relatively coarse droplets of extinguishant capable of penetrating a rising plume of combustion products to reach the burning fuel surfaces of a fire.

16. The method claimed in claim 15 wherein substantially all of the droplets of said one stream are less than one millimeter in diameter and wherein the droplets of said other stream are larger than approximately 2 millimeters in diameter.

17. The method claimed in claim 15 or 16 wherein said one stream is discharged in advance of said other stream.

18. The method claimed in claim 15 or 16 wherein said streams are simultaneously discharged from the same source.

19. The method claimed in claim 18 further comprising reducing the pressure of the extinguishant of said other stream relative to the pressure of the extinguishant of said one stream before the discharge of said streams from said source.

20. The method claimed in claim 15, 16, 17 wherein said one streams are discharged from separate sources.

21. The method claimed in any of claims 15 to 20 wherein one stream and said other stream are discharged in response to different information received from the fire.

22. The method claimed in any of claims 15 to 20 wherein said one stream and said other stream are discharged in response to the same information received from the fire.

23. The method claimed in any of claims 15 to 20 wherein the said one stream is discharged in response to actuation of first temperature-responsive means, and the other stream is discharged in response to actuation of separate second temperature-responsive means.

24. The method claimed in any of claims 15 to 23 wherein a plurality of each of said streams is discharged, said one stream providing maximum cooling effect near the ceiling of the building being protected, said other streams providing maximum fire fighting capability, said one stream inhibiting the

activation of said other streams to reduce the number of ther streams to those over the fire area and thereby help insure an ample supply of water for fighting the fire.

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Chartered Patent Agent,
Agents for the Applicant(s).

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Fig. 1.

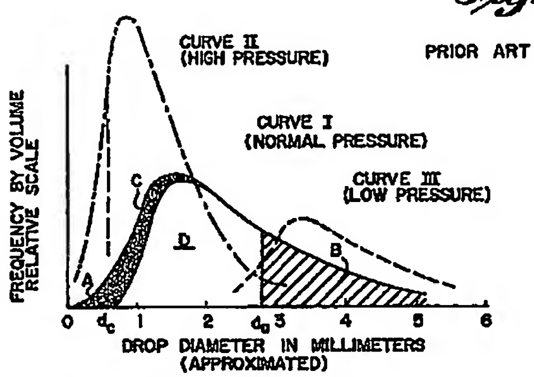
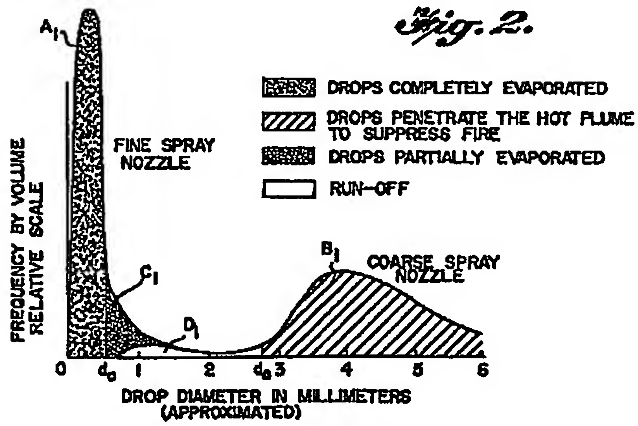

CURVE II
(HIGH PRESSURE)
PRIOR ART
CURVE I
(NORMAL PRESSURE)
CURVE III
(LOW PRESSURE)
FREQUENCY BY VOLUME
RELATIVE SCALE
C
D
B
A
0
d_c
1
2
d_a
3
4
5
6
DROP DIAMETER IN MILLIMETERS
(APPROXIMATED)

Fig. 2.


A_1
DROPS COMPLETELY EVAPORATED
DROPS PENETRATE THE HOT PLUME TO SUPPRESS FIRE
DROPS PARTIALLY EVAPORATED
RUN-OFF
FINE SPRAY NOZZLE
FREQUENCY BY VOLUME
RELATIVE SCALE
C_1
D_1
B_1
COARSE SPRAY NOZZLE
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d_c
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d_a
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6
DROP DIAMETER IN MILLIMETERS
(APPROXIMATED)

Fig. 3.

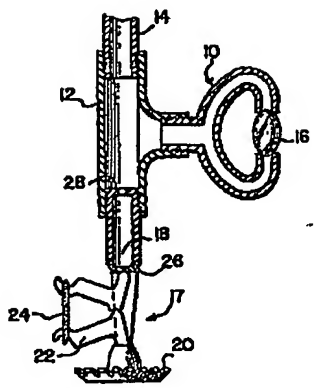

Fig. 4.

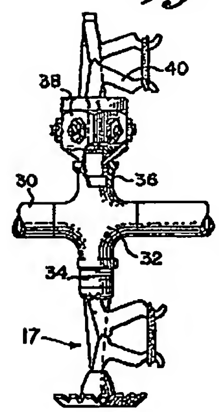

Fig. 5.

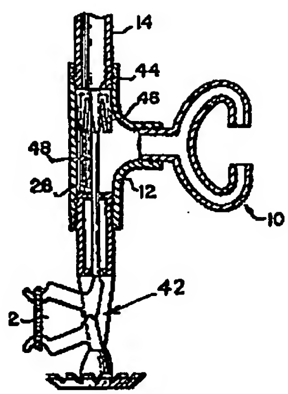

Fig. 6.

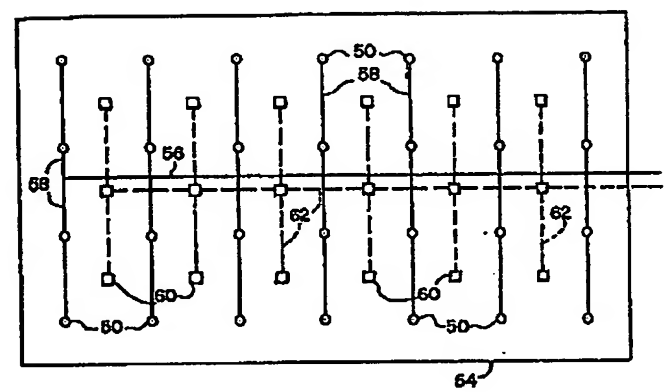

Fig. 7.